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COMPUTERIZING A GOVERNMENT DATA SYSTEM: A MANAGEMENT OVERVIEW OF THE STEPS REQUIRED AND THE TIME NEEDED

M. V. Jones

JULY 1969

Prepared for

EDP EQUIPMENT OFFICE

ELECTRONIC SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
L. G. Hanscom Field, Bedford, Massachusetts

Project 8510
Prepared by
THE MITRE CORPORATION
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FOREWORD

The work reported in this document was performed by The MITRE Corporation, Bedford, Massachusetts, for the EDP Equipment Office, Electronics Systems Division of the Air Force Systems Command under Contract AF19(628)-68-C-0365.

REVIEW AND APPROVAL

Publication of this technical report does not constitute Air Force approval of the report's findings or conclusions. It is published only for the exchange and stimulation of ideas.

ROBERT L. JONES, Colonel, USAF
Chief, EDP Equipment Office

ABSTRACT

This paper discusses what must be done and how long it will take to convert a manual data system in a government agency to a computerized system. Seven (7) major tasks are identified, 78 steps involved in carrying out these major tasks are enumerated, and 50 considerations that can affect the time required for accomplishing these tasks in specific cases are described. Minimum and maximum time estimates for completing each major task are also included. The paper aims to provide a relatively brief, non-technical overview of the topics covered and is addressed primarily to the thousands of managerial personnel at all levels of government (federal, state, and local) who have had relatively little prior experience with electronic computers.

ACKNOWLEDGMENTS

On pages 4 - 6 we discuss where we obtained the information to write this report. Some of the written materials we used are listed in Appendix I.

Special acknowledgment is due to Michael J.Flax who assisted in the research and provided valuable counsel on the entire content as well as on its presentation.

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INTRODUCTION

The Literature

A large and growing literature covers in depth many things about the electronic computer. A relatively neglected question - one that this paper addresses - is how to estimate the length of time required to computerize a manual data system, i.e., to convert a manual system to an automated system.

The enormous volume of research and writing in the computer field covers three principal areas - technology, applications, and management. First, much time and talent have been spent in refining computer technology - in developing more sophisticated computer equipment and improved methods of computer utilization. Second, many experts have devoted their energies to identifying problems in science, business, government and the professions that can be solved by an application of computer technology. Third, much has been written to help managers effectively implement the new computer systems and to control them once implemented.

The many management-oriented books and articles on computers also cover a wide range of subjects. Many writers have sought to bridge the communications gap between the manager and the computer expert by explaining simply the terms and concepts that computer experts use. Other writers have discussed what a manager can do to facilitate the transfer from a manual to a computer system. Among the questions covered are: where the Electronic Data Processing (EDP) function should be placed organizationally in a company or agency, what types of personnel are needed to implement and operate the computer activity, how to cope with the serious human relations problems that often develop when a long established manual data system is computerized, how to select the type and model of computer equipment to be acquired, whether to buy or lease this equipment, and what it is likely to cost to install a computer system.[1]

This Paper's Scope

This paper, as noted in the first paragraph, discusses several questions relative to the length of time required

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1. A prior MITRE study discusses techniques for costing computer equipment (M.V.Jones "Costing Computers for Command and Control Systems" in MITRE MTR-508, An Approach to Command and Control Systems Costing, The MITRE Corporation, Bedford, Massachusetts, September 1967)

to convert a manual data system to a computerized system. Four major issues are discussed:

1. What major tasks must be completed to make this conversion?

2. What are the representative steps involved in accomplishing these major tasks?

3. How long a time period (expressed in a range) is required to complete each of these major tasks?

4. What considerations are important in determining, whether in any particular computer application, a relatively short time period or a long time period, will be required to complete any major task.

Several things about the way we handle this subject should be noted:

1. Our time-span, compared to most other studies, is relatively long. We cover the period from when the decision is made to computerize an activity through the time that the computerized system is installed. We do not cover the operation and maintenance periods.

2. Our discussion is descriptive, not prescriptive. We try to tell what has been historical experience relative to time considerations in converting manual data systems

to automated data systems. We hope that managers will find our discussion useful in planning and implementing their own computerized data systems. It is not, however, a major objective of this paper to advise managers on how to minimize the time required for this conversion.

3. Our discussion applies most to government agencies that have relatively formal procedures for making managerial decisions including procurement decisions.

4. Within the group of such agencies this paper primarily addresses management-type personnel who have had limited prior experience with computers. However, many of the issues we discuss also confront managers undertaking to update or expand an existing automated data system.

5. We try to give the management group that we address a brief, simple background orientation on the matters we discuss rather than a User's Manual to plan and control in detail the time aspects of the computer function.

Our Sources

It was hard to collect relevant data for this study. We found this somewhat surprising, since during the last

10 to 15 years over 50,000 computers have been built and installed in this country. However, as far as we could determine, no computer expert has ever written a book or a major report that would document this substantial body of experience.

One reason for this data problem is that some of the information on this subject is closely held. For instance, computer manufacturers are reluctant to release delivery-time information on their machines. Computers and Automation, a trade journal, publishes a "Monthly Computer Census," but has had extreme difficulty in getting major manufacturers to provide data relative to the total number of computers installed, the number of unfilled orders, etc. The Auerbach Corporation, a leading service and consultant company in the computer field, has published tens of thousands of pages of information about computers but practically nothing on time-related considerations.

Because of this data problem it was necessary that the data for this study be pieced together from literally dozens of sources, some written, some obtained by interview. Although there is no single comprehensive information

source on the matters we discuss, there are pockets of expertise. Some of the written sources that we referenced while compiling the material for this study are listed in Appendix I. The listing is far from complete because some of the materials we referenced were proprietary or were taken from informal memoranda that could not be listed.

We also talked to several dozen individuals, expert in one phase or another, of computer activities. A first draft of this report, written a year ago, was reviewed by approximately 25 people. Some of these consultants and reviewers are listed in Appendix II. Again this list is not complete because many of the contacts were informal and off-the-record. We are indebted to all who talked to us, but it should be clearly understood that the author alone is responsible for the contents of this paper.

BASIC GROUNDRULES

There is no generally-accepted standard set of tasks or steps required to computerize a manual data system. To a degree each computer expert has his own personal way of describing these tasks and steps. Some of the differences among experts can be described as semantic rather than substantive. For instance, experts differ relative to what computer programming "is." Some experts define "computer programming" very broadly to include many activities that other experts would prefer instead to classify as "task definition," "system design," or "system integration and installation." Because of these definition differences, it is only natural that experts would differ relative to the best way to describe the steps involved in writing a computer program and the time required to develop a computer program.

Apart from differences in definition, a single set of standard steps will not fit every real-world computer job for two reasons. First, some computerizing jobs are simple and straight-forward in that the data of only one or a few functions of an organization are to be computerized

and the data needed to discharge these functions are easily identified. In other instances implementing a computer system is more complex. In many of these cases a compatible, automated system must be devised to handle many diverse data functions administered by different organizational units that receive and generate different types of data. In the simple case steps can be combined or even skipped that in the complex case must be handled separately. Similarly, even when there is no substantial difference in the complexity of the data problem, a highly structured organization will be more formal in accomplishing a given task, such as the procedures utilized to select hardware and software contractors, than will a loosely-run organization.

For the reasons noted above, the tasks and steps outlined in this paper should be considered representative of most cases, but not necessarily applicable to all cases.

Similarly, although the time estimates we provide for accomplishing major tasks are expressed as ranges, rather than as single numbers, these ranges do not include all cases. Perhaps one out of every ten or twenty cases will

fall outside of the lower or upper limit of our ranges.

The tasks and steps, as we present them here, are generally sequential, e.g., a Request for Proposal must be written before it can be issued. In many cases, however, the actions can be concurrent. Site preparation work can proceed concurrently with manufacturer operations to produce and deliver equipment and with personnel actions to recruit and train manpower. Almost always the steps will be iterative in the sense that a later step will provide information dictating action to redo an earlier step. For instance, preliminary design work may lead management to review and revise the automation project's overall objectives.

This matter of iteration should be explained further. In the process of accomplishing the first major task (Task Definition and General Design - TDGD) much analysis and many decisions are accomplished on a relatively "broad-brush" basis that subsequently are redone later in more detail. For example, in the TDGD phase preliminary analyses and decisions are made relative to computer programming, site preparations, personnel training, etc.

Later when these tasks are performed intensively on the working level, the analyses and decisions made in the TDGD phase are reviewed and revised.*

The steps listed in this paper are of two types, those involving substantive, technical work that must be completed and those that represent management-supervisory approval of the substantive work. The steps involving approvals are often the most difficult to predict relative to time requirements, and, often in practice, it takes longer to obtain the necessary management approvals than it does to complete the substantive work that they are approving.

Finally, because this paper is directed to a management, rather than a technical, audience, we have tried to avoid great detail in identifying relevant steps. In many cases our steps could be subdivided into much finer detail. For instance, under the major activity, Procure-

*In a larger sense the whole process of establishing an automated data system is an unending job. After the initial system is operational, the basic objectives of the automation project are periodically reviewed and redefined, the system design is updated, new equipment is purchased and delivered, computer programs are revised and personnel are retrained.

ment Action, we list a total of 13 steps. One of these 13 steps is "Receive Proposals." However, some of the larger computer manufacturers have formalized their procedures for preparing bids to government Requests for Proposals into a series of 50 - 100 discrete actions. For the purposes of this paper there would be no point to subdividing the steps into this level of detail.

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TYPICAL TIME REQUIREMENTS

This section identifies the major tasks in computerizing a data system and provides typical time estimates for accomplishing these tasks.

EXHIBIT 1

MAJOR TASKS IN COMPUTERIZING A DATA SYSTEM

Number of Months to Complete

No.	Task	Total Months to Complete
1	Task Definition and General Design	3 - 24
2	Procurement Action	8 - 12
3	Equipment Delivery	1 - 24
4	Computer Programming	6 - 24
5	Site Preparations	2 - 18
6	Personnel Training	3 - 12
7	Installation - Conversion	3 - 12
	All Tasks	20 - 72*

*These estimates allow for the fact that certain tasks would be completed concurrently, e.g., equipment delivery and site preparations.

Exhibit 2 presents the limiting cases of Exhibit 1 in graphical form. In Exhibit 2 the numbers below each line refer to the major tasks listed in column 1 of Exhibit 1. The number above the line in Exhibit 2 indicates the number of months required to complete major action on the specific task referenced below the line.

In many cases major tasks would proceed concurrently. For instance, preliminary action on many of the middle-to-latter steps will often begin earlier than Exhibit 2 indicates. Thus, some personnel training may start in the task definition-general design period. Similarly preliminary site preparations may begin as soon as the general design has been firmed up. In Exhibit 2 we have tried to use "reasonable" assumptions relative to these concurrencies. What is "reasonable" is, of course, debatable.

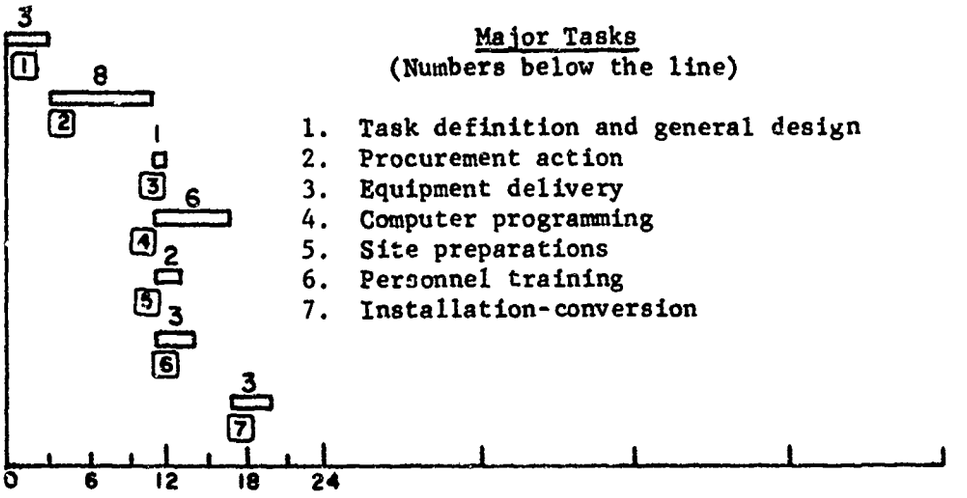
It has been noted previously that the time estimates provided in this paper do not take account of the extreme delays that can sometimes occur in automating a data system. Exhibit 2 has been drafted on this basis. For instance, the site preparation time will be much longer than we have shown if

EXHIBIT 2

TYPICAL TIME REQUIREMENTS FOR COMPUTERIZING A DATA SYSTEM

A Short Time Requirement

(The estimated time requirements for a simple computerizing job in which the management encounters more good luck than bad in making the conversion.)

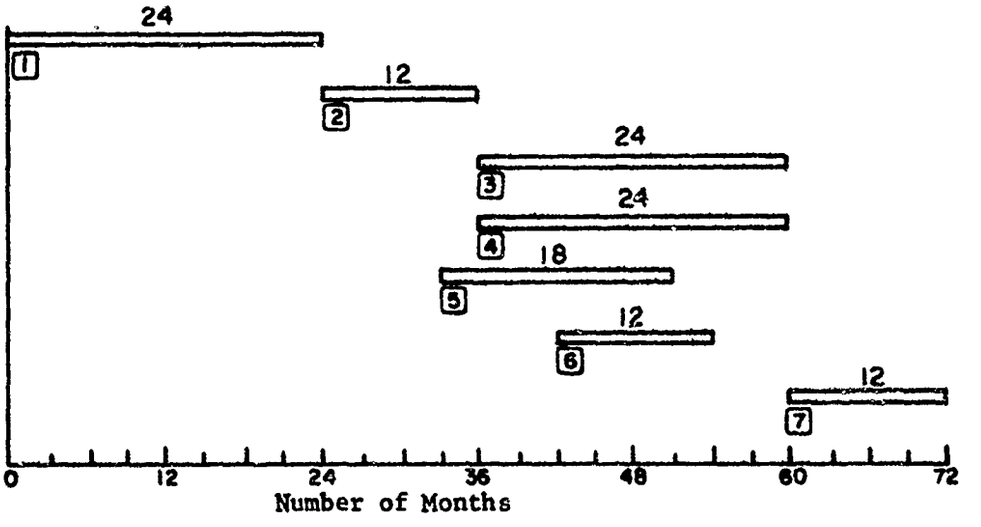


Major Tasks
(Numbers below the line)

1. Task definition and general design
2. Procurement action
3. Equipment delivery
4. Computer programming
5. Site preparations
6. Personnel training
7. Installation-conversion

A Long Time Requirement

(The estimated time requirements for a complex computerizing job in which the management encounters more bad luck than goodin making the conversion.)



a new building must be built, if an extensive site search must be conducted, if land must be purchased, if special building specifications must be written, if there are substantial delays in material delivery, or if work stoppages occur.

SEVEN MAJOR TASKS

The seven sections that follow provide in summary form a set of time related information for each of the seven major tasks involved in automating a data system that were identified in the preceding section. In each instance this time-related information consists of the following:

1. A time estimate for accomplishing the particular task being discussed. (This represents a restatement of the time estimate provided in Exhibit 1).

2. A list of the principal steps involved in completing the designated major task.

3. A list of "time determinants," i.e., the parameters or time considerations that will affect the actual length of time needed in a specific case to accomplish each major task.

4. A set of "Explanatory Notes" that briefly amplify, where needed, the statements presented under "Time Determinants."

EXHIBIT 3

TASK DEFINITION AND GENERAL DESIGN

Major Steps and Their Time Determinants

3 - 24 Months

Major Steps

1. Establish automation project.
2. Appoint project task force.
3. Assign tasks responsibilities.
4. Formulate project objectives.
5. Establish project control schedules.
6. Establish reporting - review and management-control procedures.
7. Orient supervisors relative to project.
8. Survey information needs.
9. Define documentation standards.
10. Establish procedures for operational testing and acceptance of the new system.
11. Estimate general work load and data flow.
12. Prepare design specifications (tentative) for the new system.
13. Evaluate, debug, and redesign proposed system.
14. Determine what additional equipment and types of software are needed.
15. Evaluate in terms of financial and other criteria alternative means of acquiring the needed computer resources (lease vs. buy, etc.).
16. Obtain management approval for all aspects of the new system.

Time Determinants

1. Magnitude and complexity of the data-processing requirement.
2.* Stability of this requirement.
3.* The number and diversity of the administrative approvals needed.
4.* Quality of documentation on existing system.
5.* Quantity and quality of effort applied to the job.
6.* Time actually available for developing and implementing the new system.

*Explanatory note on next page.

EXPLANATORY NOTES FOR TIME DETERMINANTS

Task Definition and General Design

2. The extent to which the data processing requirement is accurately assessed to begin with and the extent to which it changes during development of the new system.

3. The extent to which the new automated system will endanger the job responsibilities of middle management and working-level personnel plus the relative "positions of power" of key top-management executives is sometimes the major time determinant during the TDGD task.

4. The extent to which the existing data system is logically structured and well recorded so that it provides a good base from which to develop the new system.

5. The number and quality level of the personnel assigned to the conversion task including their native abilities, training and experience in EDP work, and their general motivation and morale.

6. An application of Parkinson's-law, i.e., the extent to which management and other pressures dictate that the data system conversion be accomplished quickly. When there are such pressures, normally sequential operations will be accomplished concurrently and administrative approvals expedited. However, sometimes excessive haste will complicate and delay the final installation of the new system.

EXHIBIT 4

PROCUREMENT ACTION

Major Steps and Their Time Determinants

8 - 12 Months

Major Steps

1. Convert design specifications (both equipment and software) into procurement specifications.
2. Appoint source selection board.
3. Develop criteria for selecting contractors, i.e., translate design and procurement specifications into "benchmark" tests.
4. Prepare prospective list of bidders.
5. Prepare Requests for Proposals.
6. Issue Requests for Proposals.
7. Hold bidders conference.
8. Receive proposals.
9. Validate information contained in bidders' proposals.
10. Evaluate proposals and negotiate with "responsive" bidders.
11. Select contractor(s).
12. Secure appropriate approvals (technical and managerial) of the selection(s).
13. Announce selection(s).
14. Consummate contract(s).

Time Determinants*

1.** Flexibility of procurement procedures.
2.** Complexity of the procurement specification.
3.** The type and extent of validation required.
4.** The number of reviews and concurrences required.
5. The number of bidder proposals (and their complexity) to be evaluated.
6. The number of personnel participating in the procurement action.
7. The time available for the procurement action, i.e., the extent of management interest and pressure for a quick selection.

* Experts differ whether, in what manner, and to what extent the time required to complete a computer procurement action is affected by the type of contractual arrangement - e.g., sole source vs. competitive bid, lease vs. buy, fixed price contract vs. incentive type contract, etc.

** Explanatory note on next page.

EXPLANATORY NOTES FOR TIME DETERMINANTS

Procurement Action

1. The extent to which prescribed contractual procedures can be abridged to expedite procurement.

2. Complexity as a function both of the sophistication of equipment and software to be procured and of diversity of the agency(ies)' data requirements.

3. E.g., is a "live-test" demonstration required?

4. The time required for review and concurrence will depend upon how many management echelons must review the decision and the length of time each review takes.

EXHIBIT 5

EQUIPMENT DELIVERY*

Major Steps and Their Time Determinants

1 - 24 Months

Major Steps**

1. Receive order (sign contract).
2. Schedule production.
3. Receive materials and purchased parts.
4. Fabricate non-purchased components.
5. Fabricate and test sub-assemblies.
6. Assemble end products.
7. Inspect end products.
8. Package for shipment.
9. Ship.
10. Install
11. Checkout.

Time Determinants***

1. Degree of production standardization.
2. Previous manufacturing experience.
3. Current computer market conditions.
4. Production rate of the equipment ordered.
5. Contract delivery incentive conditions.
6. Government authorization for delivery priority.

*Many types of computer equipment may be needed - a central processing unit, various types of input-output equipment, numerous off-line storage and peripheral devices, as well as "communications" equipment.

**This is a listing of a manufacturer's major activities covering a regularly produced, off-the-shelf item requiring no new product design, new tooling, or make-or-buy decisions deviating from standard production procedures for that item. Some new data systems also require system engineering and equipment modification work even if most components are off-the-shelf items.

***Explanatory notes for each of these steps are on the next page.

EXPLANATORY NOTES FOR TIME DETERMINANTS

Equipment Delivery

1. Standard, "off-the-shelf" equipment will be available more quickly than equipment necessitating extensive engineering development or production changes.

2. An item that is well past its introductory production and marketing phase will be available more quickly than a new item for which production is just getting started.

3. A temporary slack in the general computer market may reduce delivery time whereas a rapidly expanding market demand may delay delivery.

4. High demand models regularly produced in volume normally are available sooner than "top-of-the-line" models produced only on order.

5. If the contract provides a penalty for late delivery or a bonus for early delivery, delivery time may be reduced over what it would be without such provisions.

6. A special government priority (seldom invoked) can reduce delivery time; a "DX" priority authorizes shipment to a preferred buyer of the next unit off of the production line.

EXHIBIT 6

COMPUTER PROGRAMMING

Major Steps and Their Time Determinants

6 - 24 Months

Major Steps

1. Translate the general design specifications for computer programs so that the functions of and the approach to individual computer programs are clearly identified.
2. Establish operational standards to govern the systems programs.
3. Review and adapt any existing* computer programs so that they can be used in the new data system.
4. Plan, design, code, test, and debug** any additional computer programs needed for the new system.
5. Test the total set of computer programs to insure that they perform as an integrated computer program package.
6. Document all training and operating procedures for the developed computer programs.
7. Develop and implement procedures for making and documenting future changes to any aspect of the computer programming package.

Time Determinants***

1. Magnitude of the programming task.
2. Complexity of the programming task.
3. Degree of modification vs. current programs.
4. Stability of the programming requirement during the period the programs are being developed.
5. Number of programmers assigned to the task.
6. Skill level of the programming task force.
7. Suitability of the major equipment available.
8. Programming aids available.
9. Project constraints.
10. Environmental conditions.
11. "Quality" of system-design documents used by programmers.
12. The "depth" of programming documentation required.

*Existing programs may consist of sequences of computer instructions used either (1) to run any type computer program on a particular machine, or (2) to do a particular type job, e.g., generate a payroll.

**Many substeps are needed to accomplish these five major programming operations. See references on programming in Appendix I.

***Explanatory notes (except 3, 4, 5) on next page.

EXPLANATORY NOTES FOR TIME DETERMINANTS

Computer Programming

1. Magnitude is often hard to estimate, it is usually measured by estimated number of instructions to be written.

2. Some types of programs and programming languages take longer to write than others. Programming is also more complicated if data must be handled from a variety of non-standard input/output devices or if accuracy or "security" of data are important.

6. Programming is an art; skill depends on native ability, formal training and years of experience. The quality of leadership, task-force morale, etc. are also important.

7. If available computer equipment is not well suited to the data handling job, programming will take longer.

8. A ready access to the computer for debugging the program plus the availability of auxiliary debugging aids can shorten the time needed for programming.

9. Some project constraints can increase the time needed for programming, e.g., must the program be written to process data in the shortest time possible, to consume the smallest amount of computer core storage possible, etc.

10. E.g., how many different programs must a programmer work on concurrently, how closely must the work of different programmers interface, etc.

11. Quality of design documents is measured in terms of completeness, consistency, and lucidity. Whether the personnel interface among the user-designer-programming group is good or poor can affect the time needed to do the programming.

12. Depth is measured in terms of the relative detail and formality that must be achieved in documenting the programming.

EXHIBIT 7

SITE PREPARATIONS

Major Steps and Their Time Determinants

2 - 18 Months

Major Steps

1. Draft site specifications (floor space, power, air conditioning, etc.).
2. Conduct site availability - adequacy study.
3. Negotiate contract(s) for necessary site augmentation.
4. Relocate people and equipment (if building is already occupied).
5. Complete major structural work (if needed).
6. Install (or modify) power and other utilities.
7. Install (or modify) air conditioning.
8. Construct raised floor (if necessary).
9. Complete minor structural work.
10. Checkout all site preparations.
11. Move in equipment and people.

Time Determinants*

1. The number of administrative approvals required for the site preparations.
2. The availability of a suitable building.
3. The type of building that must be obtained (if none is available).
4. The extent of structural alterations required if an existing building is to be modified.
5. The adequacy of environmental control systems.
6. The adequacy of the power plant and other utilities.

*Explanatory notes on next page.

EXPLANATORY NOTES FOR TIME DETERMINANTS

Site Preparations

1. The time needed for administrative approvals of the site plans will be directly related both to the number of approvals required and their echelon level. Delays in approval may occur if an existing organizational unit must be forced to relinquish its space to the new computer unit. Congressional approval is needed for new building construction that requires large sums of money.

2. This factor is often the most important in determining the time required for site preparations. Site preparations will be prolonged if a new building must be designed, approved, financed, and built.

3. E.g., some government agencies have taken to housing their computers in vans because Congressional (fixed installation) approval is not required for such housing.

4. Areas to be checked for adequacy include: square footage, floor loading capacities, doorways, elevators, loading docks, lighting, raised floor, walls moved, vaults, "secure areas," radio-frequency shielding requirements, etc.

5. Includes such items as air, temperature, and humidity control systems.

6. Includes such items as electrical, plumbing, and related utilities.

EXHIBIT 8

PERSONNEL TRAINING*

Major Steps and Their Time Determinants

3 - 12 Months

Major Steps

1. Study operations to be performed.
2. Analyze types and numbers of personnel required.
3. Write position descriptions.
4. Survey personnel availability to determine the number that can be transferred vs. the number that must be recruited.
5. Determine training requirements.
6. Establish training milestones.
7. Draft training program.
8. Develop and/or procure training aids and facilities (training equipment, building space, manuals, etc.)
9. Select and train instructors.
10. Trial-test and refine training programs.
11. Recruit and select personnel to be trained.
12. Train personnel (operating, maintenance, and other).

Time Determinants**

1. Market conditions for computer personnel.
2. Depth of the existing personnel "base."
3. Degree of newness of the new data system.
4. System complexity (equipment and computer programming).
5. Presence of built-in self-testing and self-diagnosis characteristics in the new system.

*Training must be provided both for those who will operate the Computer Center and for those who will use its services.

**Explanatory notes on next page.

EXPLANATORY NOTES FOR TIME DETERMINANTS

Personnel Training

1. E.g., national and local supply conditions for required types of personnel, the competitive status of a particular employer relative to wages and terms of employment, etc.

2. E.g., are position descriptions, training plans, transferable trained personnel available or must they be developed "from scratch"?

3. The magnitude of the change in the new system vs. the old system relative to equipment and computer programming. Is a change in vendors involved?

4. Apart from newness, a complex system will require a longer time than will a simple system, both for recruiting and training personnel.

5. Built-in features will reduce the skill level required for operating and maintenance personnel and hence shorten the time needed for recruiting and training such personnel.

EXHIBIT 9

INSTALLATION-CONVERSION

Major Steps and Their Time Determinants

3 - 12 Months

Major Steps

1. Establish standard procedures, including procedures for effecting changes.
2. Start experimental operation of new system.
3. Debug new operations.
4. Refine system design.
5. Make full system test.
6. Convert files.
7. Operate old and new system in parallel.
8. Phaseout old system.

Time Determinants

1.* Degree of interface between old and new system.
2. Efficiency with which prior, major tasks were accomplished.
3. Stability of data system specifications.
4.* User-Developer-Producer-Installer Relationships.
5. Reliability of delivered Hardware-Software.
6. Capability of user's staff.
7.* Amount and types of vendor support.
8.* Criterion used to evaluate the installation.

*Explanatory notes on next page.

EXPLANATORY NOTES FOR TIME DETERMINANTS

Installation-Conversion

1. E.g., must certain files of the old data system be preserved; is a change of vendors involved, must one manufacturer's equipment be interfaced with another's?

4. Good rapport among these groups will facilitate the conversion, poor rapport will slow conversion. The larger the number of groups that must coordinate in the installation period, the greater are the chances for delay.

7. If vendors furnish substantial support, covering both hardware and software, installation will be expedited. If not, installation will lag.

8. Is the criterion that the installed system merely work, or that it work at a high level of efficiency?

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SUMMARY

1. This paper discusses time-related considerations pertaining to the computerizing of a data system in a government agency. The considerations covered are: what major tasks must be accomplished, what specific steps must be completed, how long a time period is each of the major tasks likely to take, and what factors are likely to influence this time requirement in particular applications.

2. This paper analyzes the data automation question from the perspective of a large government agency and addresses primarily managers in such agencies who have had limited prior experience with computers. We have sought to give this audience a gross familiarity with the issues discussed, not a User's Manual that they can employ to control their data automation programs.

3. In terms of qu ıtitative bench marks, the paper identifies 7 major tasks, 78 steps, and 50 time-related parameters.

4. Our time e imates for establishing a major automated data system are probably longer than most managers unfamiliar with the process are likely to expect. From initial action

to system implementation we estimate that the time required is likely to range from a little less than two years to a little more than six years.

5. Time is consumed in two types of activities in automating a data system. One set of activities consists of substantive technical and analytical work. The second consists of actions directed toward getting management and working level personnel approval of the substantive work. The latter actions sometimes take longer than the former.

6. A Parkinson-like law influences the time requirements for accomplishing much of this work, i.e., the time required depends on the time available. Especially in the case of securing administrative approvals, pressures to resolve an issue that emanates from either within an organization or external to it may force a decision that otherwise would be delayed for a long time. This point should not, however, be pushed too far. Undue haste in completing earlier tasks often complicates and delays the completion of later tasks.

NEEDED FUTURE RESEARCH

This paper has sought to familiarize management-level personnel with a complex, important problem that has been relatively neglected up to now. However, we have provided only a brief overview; each of the issues discussed should eventually be researched in greater depth than we have been able to do here. Some of the specific areas worthy of further study are the following:

1. We have stopped in this paper at providing generalized time estimates for the seven major tasks involved in automating a data system. This analysis should be extended in two ways. First, the time analysis should be differentiated for several typical "classic" cases. Second, the time estimates should be extended from the 7 major tasks to the 78 related steps.

2. This paper has listed 50 factors that can influence the time required to complete the seven major data-automation tasks. Further research should aim to provide guidance as to which of these factors are most important to a manager trying to minimize the time consumed in various types of data automation projects.

3. Only passing consideration has been given in our study to the question of concurrencies, to the matter of accomplishing various steps concurrently. A future study should research to what extent such steps have actually been completed concurrently in the past and to what extent it is desirable for the managers to aim to do so in the future.

4. This paper has focused on the process of converting manual data operations to an automated system. (We have mentioned in passing that much of this analysis is also applicable to updating a data system that is already automated). A future study should concentrate on this later issue because many federal government agencies have long since passed the stage of development discussed in this paper.

5. Our assumption has been that an agency that had not automated its data system would choose to do so by acquiring its own computer. Many users today, however, are choosing to purchase the automated data services they require from a computer service bureau, or a "computer utility" rather than to purchase computer equipment and

set up their own computer center.* A user that chooses to go this route will face variations of many of the tasks discussed in this paper such as task definition, selecting contractors, training personnel in the basics of data processing, and converting files from a manual to an automated basis. However, some of the required steps and the relevant time-determining parameters are substantially different. The whole area is worthy of a separate research study.

6. As noted earlier in the paper, we have not tried to be prescriptive; although we do hope that managers will find our discussion useful in planning and implementing their own computerized data systems. A worthwhile future study would seek to develop a set of specific, detailed guidelines that a manager could use to minimize the time required to establish an automated data system.

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*A good orientation on the potentialities of the computer utility are provided in: Parkhill, D. G., The Challenge of the Computer Utility, Addison-Wesley Publishing Co., Reading, Mass., 1966; and Barnett, C. C. and Associates, The Future of the Computer Utility, American Management Association, New York, 1967

APPENDIX I

REFERENCES USED IN WRITING THIS PAPER

Adams, Donald L., "Planning Checklist for a Computer Installation" Datamation, June 1967, pp. 37-39

The American Federation of Information Processing Societies, An AFIPS Report: The State of the Information Processing Industry, New York, New York, April 1966

Albers, Dewey M., "Developing Generalized Applications Packages," Data Processing Magazine, June 1968, pp. 24-27

Armer, Paul, Computer Aspects of Technological Change, Automation, and Economic Progress, The RAND Corporation, April 1967

Awad, Elias M., Business Data Processing, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1965 (especially chs. 21 and 22)

Barnett, C. C. & Associates, The Future of the Computer Utility, American Management Association, New York 1967

Brady, Rodney H., "Computers in Top-Level Decision Making," Harvard Business Review, July-August 1967, pp. 67-76

Brandon, Dick H., Management Standards for Data Processing, D. Van Nostrand Company, Inc., Princeton, New Jersey, 1963

Budd, A.E., A Method for the Evaluation of Software: Executive, Operating or Monitor Systems, ESD-TR-66-113, The MITRE Corporation, Bedford, Massachusetts

Canning, R. G. and Sisson, R. L., The Management of Data Processing, Jonn Wiley & Sons, Inc., New York, 1967

Carlson, Walter M., "A Management Information System Designed by Managers," Datamation, May 1967, pp. 37-43

Clark, Robert N., Nelson, Edward A. and Petersen, Kenneth E., Data Automation Resource-Reporting and Management System, System Development Corporation TM-3558, August 1967

Committee on Government Operations (House of Representatives), Automatic Data Processing Equipment, U.S. Government Printing Office, Washington, House Report No. 802, 1965

Connelly, J. J., Current Basic Sources of ADP Information, System Development Corporation, 1966

Datamation Magazine, Automatic Data Processing Glossary, F. D. Thompson Publications, Inc., Greenwich, Conn., 1968

Delaney, William A., "Predicting the Costs of Computer Programs," Data Processing Magazine, October 1966, pp. 32-34

The Diebold Group, Inc., "A Checklist for Managers," Automatic Data Processing Newsletter, June 7, 1965

The Diebold Group, Inc., "Planning for Tomorrow's Technology," Automatic Data Processing Newsletter, August 2, 1965

Farr, Leonard; LaBolle, Victor and Willmorth, Norman E., Planning Guide for Computer Program Development, System Development Corporation TM 2314, May 1965

Fete, Harry H., The Computer Challenge to Urban Planners and State Administrators (The American University Technology of Management) Series, Volume 2), MacMillan & Company, Ltd., London, 1965

Fleishman, T., Current Results from the Analysis of Cost Data for Computer Programming, System Development Corporation TM-3026, July 1966

Fletcher, Allan, Computer Science for Management, Brandon Systems Press, New York, 1967

Fried, Louis, "Estimating the Cost of System Implementation," Data Processing Magazine, March and April 1969, pp. 32-35 and 24-28

Garrity, John T., "Top Management and Computer Profits," Harvard Business Review, July-August 1963, pp. 8-12

Glaser, George, "Computers in the World of Real People," Datamation, December 1968, pp. 47-56

Gregory, Robert H. and Van Horn, Richard L., Automatic Data-Processing Systems, Wadsworth Publishing Company, Inc., Belmont, Calif. 1964

IBM Study Organization Plan - The Method Phase I, IBM, 1963

IBM Study Organization Plan - The Method Phase III, IBM, 1963

IBM Study Organization Plan - The Approach, IBM, 1963

Joslin, Edward O., Computer Selection, Addison-Wesley Corp., Reading, Mass., 1968

Kanter, Jerome, The Computer and the Executive, Prentice-Hall, Inc., Englewood Cliffs, New York, 1967

Kelly, James E., Jr. and Walker, Morgan R., Critical-Path Planning and Scheduling, Proceedings of the Eastern Joint Computer Conference, 1959

Lecht, Charles Philip, The Management of Computer Programming Projects, American Management Association, Inc., New York

Lobel, Jerome, "The Economic Aspects of EDP," Data Management, September 1966, pp. 14-25

Martin, James, Programming Real-Time Computer Systems, Prentice-Hall Englewood Cliffs, New Jersey, 1965

Matthews, M. V., "Choosing a Scientific Computer for Service," Science, Volume 161, 5 July 1968, pp. 23-27

Mayer, Martin, "Computers on the Brain," Esquire, January 1969, pp. 100-103

Myers, Charles A. (Editor), The Impact of Computers on Management, MIT Press, Cambridge, Mass. 1967

Planning the Third Generation Computer System at the George C. Marshall Space Flight Center, National Aeronautics and Space Administration, Slidell, La., June 1967

Nelson, Edward A., and Fleishman, Thomas, Cost Reporting for Development of Information Processing Systems, Air Force Systems Command, ESD-TR-67-452, April 1967

Neivergelt, J., "Computers and Computing - Past, Present, Fugure," IEEE Spectrum, January 1968, pp. 57-61

Opler, Archer, "The Receding Future," Datamation, September 1967, pp. 31-32

Parkhill, D. F., The Challenge of the Computer Utility, Addison-Wesley Publishing Company, Reading, Massachusetts, 1966

Porter, J.D. and Rudwick, B.H., Applications of Cost-Effectiveness Analysis to EDP System Selection, ESD-TR-67-412, MITRE Corporation, Bedford, Mass., 1967

Rector, Robert W. and Walter, C. J., "The Fourth - Another Generation Gap?" Modern Data, March 1969, pp. 42-48

Resove, Perry E., Developing Computer-Based Information Systems, John Wiley and Sons, Inc., New York, 1967

Searle, Lloyd V. and Henderson, Robert L., System Engineering Guide for Computer Programs, System Development Corporation, ESD TR 68-1 March 1968

Semling, Harold V., "World's Largest Computer User," Modern Data, March 1969, pp. 50-53

Sisson, Roger L. and Richard G. Canning, A Manager's Guide to Computer Processing, John Wiley and Sons, Inc., New York, 1967

Smith, Paul T., How to Live with Your Computer, American Management Association, New York, 1965

Stuart, Fredric, Introductory Computer Programming, John Wiley & Sons, Inc., New York, 1966

Taylor, James W. and Dean, Neal J. "Managing to Manage the Computer," Harvard Business Review, September-October, 1966, pp. 98-110

Withington, Frederic G., The Use of Computers in Business Organizations, Addison-Wesley Publishing Company, Reading, Mass., 1966

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13. ABSTRACT

This paper discusses what must be done and how long it will take to convert a manual data system in a government agency to a computerized system. Seven (7) major tasks are identified, 78 steps involved in carrying out these major tasks are enumerated, and 50 considerations that can affect the time required for accomplishing these tasks in specific cases are described. Minimum and maximum time estimates for completing each major task are also included. The paper aims to provide a relatively brief, non-technical overview of the topics covered and is addressed primarily to the thousands of managerial personnel at all levels of government (federal, state, and local) who have had relatively little prior experience with electronic computers.

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